

## Set 30: Reaction Stoichiometry Part I

**Skill 30.01:** Be able to classify a stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

**Skill 30.02:** Identify the steps required to solve each type of stoichiometry problem

**Skill 30.03:** Be able to identify the mole ratio between two substances in a chemical reaction

**Skill 30.01:** Be able to classify a stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

### Skill 28.01 Concepts

The branch of chemistry that deals with the mass relationships among reactants and products in a chemical reaction is *stoichiometry*. All of the reaction-stoichiometry problems in this course can be classified as one of four types:

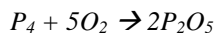
1. mole – mole
2. mole – mass
3. mass – mole
4. mass – mass

Each type is defined in terms what is given and what is unknown in the problem. Consider the following example:

#### Example

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

*Phosphorous readily reacts with atmospheric oxygen to form diphosphorous pentaoxide as shown below:*



*If 2.0 g of phosphorous react with excess oxygen, how much in moles of diphosphorous pentaoxide can be produced.*

#### Solution

In the problem you are *given* the mass of phosphorous (P<sub>4</sub>): 2.0 g

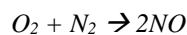
You are asked to find the moles of diphosphorous pentaoxide (P<sub>2</sub>O<sub>5</sub>): ? moles

Therefore this is a mass-mole problem.

**Skill 30.01 Problem 1**

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

*Atmospheric oxygen reacts with nitrogen in automobile engines to produce NO, a poisonous greenhouse gas*

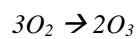


*If 5 moles of nitrogen react, how much oxygen gas in moles is consumed?*

**Skill 30.01 Problem 2**

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

*In the lower atmosphere where we live, NO and UV light catalyze the production, O<sub>3</sub> from O<sub>2</sub> as shown,*



*If 5 moles of oxygen react, how much in grams of ozone is produced?*

**Skill 30.02: Identify the steps required to solve each type of stoichiometry problem****Skill 30.02 Concepts**

Once the stoichiometry problem has been classified, the steps required to solve the problem must be identified. Figure 1 summarizes the four types of stoichiometry problems along with steps required to solve them:

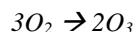
**Figure 1.** Steps for solving the four types of stoichiometry problems

Type	Description	Steps
mole –mole	In a <i>mole-mole</i> problem, you are given the moles of one substance and asked to calculate the moles of another substance in the chemical reaction.	moles given → moles unknown
mole-mass	In a <i>mole-mass</i> problem, you are given the moles of one substance and asked to find the mass of another substance in the chemical reaction	moles given → moles unknown → mass unknown
mass – mole	In a <i>mass-mole</i> problem, you are given the mass of one substance and asked to find the moles of another substance in the chemical reaction	mass given → moles given → moles unknown
mass –mass	In a <i>mass-mass</i> problem, you are given the mass of one substance and asked to find the mass of another in the chemical reaction	mass given → moles given → moles unknown → mass unknown

**Skill 30.02 Problem 1**

Identify the steps required to solve the problem below:

*In the lower atmosphere where we live, NO and UV light catalyze the production, O<sub>3</sub> from O<sub>2</sub> as shown,*



*If 500.0 g of oxygen react, how much in grams of ozone is produced?*

**Skill 30.03: Be able to identify the mole ratio between two substances in a chemical reaction**

**Skill 30.03 Concepts**

Each of the four types of stoichiometry problems require the use of a mole ratio. The mole ratio is the conversion factor that relates the number of moles of any two substances in a chemical reaction. Consider for example the chemical equation for the electrolysis of aluminum oxide to produce aluminum and oxygen:



According to this reaction,

2 moles of  $\text{Al}_2\text{O}_3$  yields 4 moles of Al and 3 moles of  $\text{O}_2$

In other words,

$$\text{There are 2 moles of } \text{Al}_2\text{O}_3 \text{ for every 4 moles of Al} = \frac{2 \text{ mole } \text{Al}_2\text{O}_3}{4 \text{ mole Al}} \text{ or } \frac{4 \text{ mole Al}}{2 \text{ mole } \text{Al}_2\text{O}_3}$$

$$\text{There are 2 moles of } \text{Al}_2\text{O}_3 \text{ for every 3 moles of } \text{O}_2 = \frac{2 \text{ mole } \text{Al}_2\text{O}_3}{3 \text{ mole } \text{O}_2} \text{ or } \frac{3 \text{ mole } \text{O}_2}{2 \text{ mole } \text{Al}_2\text{O}_3}$$

$$\text{There are 4 moles of Al for every 3 moles of } \text{O}_2 = \frac{4 \text{ mole Al}}{3 \text{ mole } \text{O}_2} \text{ or } \frac{3 \text{ mole } \text{O}_2}{4 \text{ mole Al}}$$

### Skill 30.03 Problem 1

For each of the problems below:			
(a) Balance the reaction (b) Classify the problem as: mole-mole, mass-mole, mole-mass, or mass-mass (c) Identify the mole ratio between the unknown and the given substances			
Item	Problem	Classification	Mole ratio
1	What mass in grams of 1-chloropropane ( $\text{C}_3\text{H}_7\text{Cl}$ ) is produced if 400. g of propane react with excess chlorine gas according to the equation  $\text{___C}_3\text{H}_8 + \text{___Cl}_2 \rightarrow \text{___C}_3\text{H}_7\text{Cl} + \text{___HCl}$		
2	How many grams of chlorine gas are required to react completely with 10.00 grams of sodium?  $\text{___Cl}_2 + \text{___Na} \rightarrow \text{___NaCl}$		
3	The Haber process for process for producing ammonia commercially is represented by the equation below. To completely convert 9.0 mol hydrogen gas to ammonia gas, how many moles of nitrogen gas are required?  $\text{___N}_2 + \text{___H}_2 \rightarrow \text{___NH}_3$		
4	How much sodium acetate, in grams, can be produced from 2.5 grams of sodium bicarbonate and excess acetic acid ( $\text{HC}_2\text{H}_3\text{O}_2$ )?  $\text{___HC}_2\text{H}_3\text{O}_2 + \text{___NaHCO}_3 \rightarrow \text{___NaC}_2\text{H}_3\text{O}_2 + \text{___CO}_2 + \text{___H}_2\text{O}$		
5	How much oxygen, in moles, can be produced from 3.0 grams of potassium chlorate?  $\text{___KClO}_3 \rightarrow \text{___KCl} + \text{___O}_2$		